Age-related Differences in Attentional Failures during Driving: A Self-report Measure

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Older drivers experience increasing risks of vehicle crashes. This increase in crash risks has been associated with age-related declines in attention. To assess attentional failures during driving, we develop a self-report measure, the Attentional Failures during Driving Questionnaire (AFDQ). In this paper, we describe the development of the questionnaire and our preliminary effort to examine its reliability and validity via an online survey. The results demonstrated a high level of internal consistency of the questionnaire. In addition, we found that self-reported attentional failures during driving are not only associated with self-reported attentional and cognitive failures during other daily activities, but also related to unsafe driving behaviors and self-efficacy in driving. Our results also showed significant age-related differences in the AFDQ score: old-old drivers (age 75+) reported a higher level of attentional failures during driving than middle-aged drivers (age 25-64) and young-old drivers (age 65-74). These preliminary results indicate the potential use of AFDQ as a measure of attentional performance during driving for older drivers.

Older drivers are the fastest growing segment of the driver population in the United States. Older drivers have higher risks of involvement in fatal crashes per mile driven than any other age groups (Tefft, 2012). Higher risks in vehicle crashes among older drivers have been associated with age-related declines in attention (Ball et al., 1993; Bédard et al., 2007).

Attention is the ability to concentrate on one part of the environment while ignoring others. Many aspects of attention, including sustained attention (Akerstedt et al., 2005), divided attention (Novack et al., 2006), selective attention (Trick et al., 2004) and spatial coverage of attention (Coeckelbergh et al., 2002) have been associated with driving safety.

Sustained attention, often termed vigilance, is the ability to maintain focus on one task over a period of time. Safe driving requires a driver to continuously monitor the environment and vehicle status. Being inattentive at any given moment may lead to driving hazard. For example, failing to realize that the traffic light has turned red while following the vehicle ahead at an intersection may result in a vehicle crash.

Divided attention is the ability to pay attention to multiple processes. During driving, attention may be divided among multiple spatial locations (e.g., attending to the forward road condition while also being attentive to road-side information such as an exit sign), among multiple tasks (e.g., driving while talking to a passenger), or among multiple sensory modalities (e.g., maintaining visual attention on the main road while listening to instructions from a GPS device).

Selective attention describes the ability to focus on a particular part among information. Efficient selection of information from a visual clutter is essential during driving. For example, if a driver cannot select information from a message board showing lane directions within a few glances, the driver will likely have trouble choosing the correct lane.

Spatial coverage of attention refers to the spatial area of the visual field from which information is processed by attention. Attention across an extended visual field is required for safe driving. Drivers need to detect potential hazards across an extended visual field, particularly in the peripheral areas. Poorer spatial coverage of attention has been associated with higher vehicle crash risks (Ball et al., 1993).

Deterioration with age has been found in all of the above aspects of attention: sustained attention (Berardi, Parasuraman & Haxby, 2001), selective attention (Madden & Langley, 2003), spatial coverage of attention (Ball et al., 1988), and divided attention (particularly when the task involves monitoring novel information, Tun & Wingfield, 1995).

Self-monitoring of driving ability can help older drivers to prepare for impacts from age-related cognitive declines on driving performance. In particular, a questionnaire or a checklist that assesses attentional failures during driving can be a convenient and effective measure that can be self-administrated. Such a tool would provide older drivers with insights into their crash risks due to attentional declines, thus may help to improve driving safety of older drivers.

There are a few self-report tools developed to measure driving performance. For example, the American Automobile Association (AAA) provides a checklist for older drivers – Drivers 65 Plus: Check Your Performance – to examine individuals' driving performance. More widely used in research on driving performance, the Manchester Driver Behavior Questionnaire (DBQ) has been adopted to investigate age-related changes in driving errors, lapses, and violations (Reason et al., 1990). The research found that while driving violations declined with age, driving errors did not (Reason et al., 1990). Although these questionnaires are informative about driving performance in general, they do not particularly focus on attention-related driving abilities which have been identified as a major factor in crash risks of older drivers (Bédard et al., 2007; Horswill, et al., 2008). A questionnaire measuring attentional failures during driving can help individual older drivers to stay informed about their driving abilities and keep monitoring their abilities; the questionnaire can also be used to investigate how aging impacts various attentional functions in the context of driving.

This paper describes our effort to develop a self-report measure of attentional failures in the context of driving: the *Attentional Failures during Driving Questionnaire (AFDQ)*. We present the construct of the questionnaire, and preliminary results from a survey study examining the reliability and validity of the questionnaire. We compare the scores from AFDQ to well-established questionnaires on self-reported attentional and cognitive abilities, unsafe driving behavior, and self-efficacy in driving.

Questionnaire Development

A set of initial items was first constructed by the authors. The items were then narrowed down based on the discussions among researchers, and comments from colleagues who are experts in the research field. In the version used in this survey study, AFDQ consists of 33 questions in four categories of attention: sustained attention, divided attention, selective attention, and spatial coverage of attention. The questionnaire items were designed to measure drivers' perceived frequencies of driving situations related to attentional failures in the past six months. All items are rated on a 6-point Likert scale: 'never', 'hardly ever', 'occasionally', 'frequently', and 'nearly all the time', coded as 0, 1, 2, 3, 4 and 5 respectively. An example item for each attentional aspect is provided below (the complete questionnaire is not provided due to the space limit; please contact the authors for the questionnaire).

Sustained Attention

Sustained attention items aim to assess a driver's ability to keep focusing on the essential driving task over an extended period of time. Example item: "*You forget to turn off the turn signal after a lane change has been completed*."

Divided Attention

The divided attention items are designed to assess the ability to simultaneously attend to multiple locations or multiple tasks. Example item: "*While checking an in-vehicle display (e.g. GPS screen), you fail to promptly notice that you are getting too close to the vehicle in front of you*."

Selective Attention

The selective attention items aim to measure a driver's ability to concentrate on important information while ignoring irrelevant information in a visual clutter. Example item: "*When a road message board contains a lot of content, you fail to obtain needed information from it*."

Spatial Coverage of Attention

The items for the spatial coverage of attention are designed to evaluate a driver's ability to pick out important driving information across an extended visual field. Example item: "*You are so focused on the road ahead that you fail to promptly notice a car in the next lane attempting to merge into your lane*."

Questionnaire Evaluation

After AFDQ was developed, an online survey was conducted to evaluate the reliability and validity of AFDQ. In the following sections, we report a preliminary examination of the internal consistency of AFDQ, the effect of age on its scores, and the relations between AFDQ and self-reported cognitive and attentional failures in other daily activities, self-reported driving performance and self-efficacy in driving.

Participants

Participants were recruited from online and local communities via posts and flyers. Participants were 18 years old or older with valid driver's licenses. Within a month period, 374 participants completed the survey (295 participants were from Mechanical Turk, and 79 participants were recruited online from local communities). We excluded responses from 5 participants due to being incomplete or inappropriate (e.g., responding to same rating for all questions). Our participants' age ranges from 18-85 years. Demographic information is described in Table 1. Most participants in the old-old group can be considered as active drivers: 62.5% (30 out of 48) drive at least 1,000 miles and up to over 20,000 miles over the past year, and 75% (36 out of 48) drive a few days a week or almost every day.

Table 1. Number of participants by age and gender

Age	18-24	25-44	45-64	65-74	75+	Total
Males	20	48	38	18	31	155
Females	26	85	68	22	17	219
Total	46	133	106	40	48	374

Measures

During the survey, participants reported their demographics, driving experience and history, general health condition, daily activities, attentional and cognitive abilities during everyday tasks, attentional failures during driving, driving behaviors, and self-efficacy in driving. In this paper, we focus on attentional failures during driving (measured by AFDQ) and the relation to two groups of measures: 1) attentional and cognitive abilities in everyday life; 2) self-reported driving abilities.

To measure attentional and cognitive abilities during daily activities, three scales were included:

Cognitive Failure Questionnaire (CFQ) is a self-report inventory assessing different aspects of cognitive failures in daily activities such as reading, talking, household- and work-related tasks (Broadbent et al., 1982). Participants rate the frequency of experienced cognitive failures on a 5-point Likert scale;

Attention-Related Cognitive Errors Scale (ARCES) is an instrument on a 5-point Likert scale measuring errors in everyday tasks such as keeping track of a conversation and remembering to do a task due to failures in attention (Carriere, Cheyne & Smilek, 2008);

Adult Attention Deficit and Hyperactivity Disorder (ADHD) Self-Report Scale (ASRS) is a checklist for screening adult attention deficit in the general population (Kessler et al., 2005).

To assess unsafe driving behaviors, three scales were included:

Manchester Driver Behavior Questionnaire (DBQ) (24-item version; Reimer et al., 2005) is a widely used scale with three categories of driving behaviors: errors, lapses and violations;

Susceptibility to Driver Distraction Questionnaire (SDDQ) assess the engagement of driver distraction and its voluntary and involuntary causes (Feng, Marulanda & Donmez, in press). The voluntary section measures drivers' intention to engage in distraction, while the involuntary section examines drivers' ability to ignore distractions. The involuntary section is particularly relevant to attentional failures;

Adelaide Driving Self-Efficacy Scale (ADSES) measures how confident a driver is in various driving situations such as driving at night and turning left across oncoming traffic (George, Clark & Crotty, 2007). ADSES is rated on a scale of 0 to 10, with 0 being not confident and 10 being completely confident.

Data Analyses

A mean score of responses to each AFDQ item was calculated, and the Cronbach's alpha was computed to examine the internal consistency among the questionnaire items. Scores for the cognitive measure (CFQ, ARCES, ASRS) and the driving measures (DBQ, SDDQ, ADSES) were computed according to each questionnaire's standard method. Pearson correlations were calculated to examine the relations between AFDQ and relevant self-reported measures. An ANOVA was conducted to investigate age differences in the AFDQ score.

Results

Reliability of AFDQ

The internal consistency of AFDQ is measured by Cronbach's alpha, $\alpha = .97$. The high Cronbach's alpha suggests that the AFDQ is a reliable measure. Such a high alpha also indicates that trimming of similar items in the questionnaire might be considered in the future.

Validity of AFDQ

The mean score for each questionnaire measure for each age group is presented in Table 2.

Age Differences on the AFDQ score. The AFDQ score was compared across age groups. The results of ANOVA showed significant age group differences in the AFDQ scores, F(4, 369) = 4.31, $p < .01$. Post hoc comparisons indicated that the AFDQ mean scores of the old-old driver group (age 75+; M = 1.24, SD = 1.02) was significantly higher than the 25-44 age group (M = .98, SD = .70), the 45-65 age group (M = .76, SD = .53) and the 65-74 age group (M = .82, SD = .74). However, the 75+ age group did not differ significantly from the younger group (age 18-24; M = 1.04, SD = .78). A "bathtub" shape of results showed higher means in the younger (age 18-24) and old-old (age 75+) groups compared to other age groups in between (age 25-44, 45-64, and 65-74). These results suggest that both the younger and old-old drivers are more likely to report attentional failures during driving.

Table 2. Mean scores of age groups on the measures

		Age				
Measure		**18-24**	**25-44**	**45-64**	**65-74**	**75+**
AFDQ[1]		1.04	0.98	0.76	0.82	1.24
CFQ[2]		2.66	2.45	2.37	2.09	2.41
ARCES[3]		2.73	2.42	2.47	2.18	2.50
ASRS[4]		2.11	1.77	1.42	0.83	1.25
SDDQ[5]	**Eng[6]**	2.80	2.69	2.43	2.10	2.29
	Vol[7]	3.20	3.14	3.02	2.83	2.86
	InV[8]	2.86	2.90	2.96	2.95	3.05
DBQ[9]	**Err[10]**	0.95	0.75	0.59	0.73	1.09
	Lap[11]	1.20	1.00	0.96	1.03	1.32
	Vio[12]	1.36	1.09	0.81	0.87	1.04
ADSES[13]		7.87	8.58	8.49	9.03	7.60

[1]AFDQ: Attentional Failure during Driving Questionnaire (higher scores – more failures; range: 0-5)
[2]CFQ: Cognitive Failures Questionnaire (higher scores – more failures; range 1-5)
[3]ARCES: Attention-Related Cognitive Errors Scale (higher scores – more errors; range 1-5)
[4]ASRS: Adult ADHD Self-Report Scale (higher score – greater ADHD symptoms; range: 0-6)
[5]SDDQ: Susceptibility to Driver Distraction Questionnaire (higher score-greater susceptibility to driving distraction; [6]Eng: Engagement, range 1-5; [7]Vol: Voluntary, range 1-5; [8]InV: Involuntary, range 1-5)
[9]DBQ: Manchester Driver Behavior Questionnaire (higher scores – more unsafe driving behaviors; [10]Err:Errors, range 0-5; [11]Lap: lapses, range 0-5; [12]Vio: Violations, range 0-5)
[13]ADSES: Adelaide Driving Self-Efficacy Scale (higher scores– greater confidence, range: 0-10)

Correlations between AFDQ and Other Measures. Correlations among attentional failures during driving (AFDQ), relevant measures on attentional and cognitive abilities (CFQ, ARCES, ADHD), and driving capability and efficacy (DBQ, SDDQ, ADSES) are reported in Table 3.

The results show that self-reported attentional failures during driving was positively associated with everyday cognitive failures (AFDQ-CFQ, $r = .61$ $p < .001$), attention-related errors during daily activities (AFDQ-ARCES; $r = .55$ $p < .001$), and symptoms of attention deficit (AFDQ-ASRS; $r = .46$, $p < .001$). These associations indicate that drivers who report a higher level of cognitive failures, attentional errors and symptoms of attention deficit are more likely to experience attentional failures during driving.

Our results also showed the relations between attentional failures during driving and general driving errors, inability to

Table 3. Pearson correlations between the self-report measures

Measure		AFDQ	CFQ	ARCES	ASRS	SDDQ			DBQ			ADSES
						Eng	Vol	InV	Err	Lap	Vio	
AFDQ[1]		-										
CFQ		.61*	-									
ARCES		.55*	.85*	-								
ASRS		.46*	.72*	.65*	-							
SDDQ	**Eng**	.38*	.47*	.40*	.38*	-						
	Vol	.01	.25*	.18*	.17*	.64*	-					
	InV	.26*	.24*	.17*	.22*	.01	-.08	-				
DBQ	**Err**	.76*	.56*	.50*	.47*	.34*	.03	.26*	-			
	Lap	.75*	.68*	.62*	.52*	.37*	.08	.28*	.85*	-		
	Vio	.62*	.48*	.38*	.44*	.49*	.20*	.17*	.76*	.65*	-	
ADSES		-.33*	-.35*	-.35*	-.24*	.04	.13*	-.28*	-.24*	-.33*	-.04	-

* significant correlation , $p < .05$;
[1]please refer to Table 2 for the full terms of the abbreviations.

ignore distracting information during driving, and self-efficacy in driving. There was a positive correlation between attentional failures during driving and a variety of unsafe driving behaviors, including driving errors (AFDQ-DBQ Err, $r = .76$, $p < .001$), lapses (AFDQ-DBQ Lap, r = .75, p < .001), and violations (AFDQ-DBQ Vio, r = .62, p < .001). These associations demonstrate that drivers who experience a higher level of attentional failures during driving are more likely to exhibit unsafe driving behaviors. In addition, attentional failures during driving was also associated with self-reported engagement in driver distraction (AFDQ–SDDQ Eng, $r = .38$, $p < .001$), likely because drivers who experience a higher level of attentional failures during driving are less capable of ignoring distracting information (AFDQ–SDDQ InV, $r = .26$, $p < .001$), rather than a greater intention to engage in distracting activities (AFDQ–SDDQ Vol, $r = .01$, $p = .81$). Moreover, there was a negative correlation between attentional failures during driving and drivers' self-efficacy in driving (AFDQ–ADSES, $r = -.33$, $p < .001$). Given a higher score on the efficacy scale means greater confidence, this negative association indicates that drivers who experience a higher level of attentional failures are less confident about their driving ability.

Discussion

This paper presents our preliminary efforts to develop and evaluate a self-report measure of attentional failures during driving (AFDQ). Results from the online survey suggest that AFDQ is a reliable and valid measure of drivers' attentional failures. Below is a summary of interesting observations:

- Drivers who experience more attentional failures during driving also experience a higher level of cognitive failures in other daily activities;
- Drivers with greater symptoms of attention deficits experience more attentional failures during driving;
- Drivers who report more attentional failures during driving are more likely to demonstrate a variety of unsafe driving behaviors, and are less able to suppress distraction during driving;
- Drivers who report a higher level of attentional failures during driving are less confident drivers;
- Old-old drivers (age 75+) reported a higher level of attentional failures during driving than the middle-aged (age 25-44 and 45-64) and young-old drivers (age 65-74);
- Younger drivers (age 18-24) report a high level of attention-related failures during driving, comparable to the level of old-old drivers.

Our results suggest that the AFDQ score may provide insights into older drivers' increased crash risks due to attentional declines. AFDQ may potentially be used as a self-monitoring tool for older drivers. Using questionnaire as a self-monitoring tool can be further beneficial as it is easier to implement than computer-based tests or simulated driving assessments.

Due to age-related cognitive declines, older drivers may face challenges to make good estimations of the frequency of attentional failures that they experience during driving. Deteriorations in attention may reduce older drivers' awareness of driving situations that involved attentional failures. For example, a driver may have missed a stop sign without realizing the driving error. Older drivers may also be less able to recall the attentional failures that he/she had experienced during driving, given declining memory capacity. In addition, the calculation of the frequency of attentional failures may be more difficult for older drivers given their less frequent and shorter driving trips.

However, our results indicate that age differences on attentional failures during driving can be observed using a self-report measure. Previous research found that older drivers' performance on the hazard perception test (a computerized task that measures how quickly a driver responds to the hazardous driving situations) is not related to the drivers' ratings on how well they did on the test (Horswill et al., 2011). It is possible that being aware of whether errors have been made is easier than being aware of how quickly one's responses are. Thus, our AFDQ measuring the frequency of attentional failures (i.e., errors rather than speed of response) was able to demonstrate that old-old drivers (age 75+) rated their failures much more frequently than the middle-aged and young-old drivers.

One limitation of this online survey study is the possible self-selection bias in our driver samples. Given our participants are likely those who are actively online, our sample of drivers, particularly the older groups, may be cohorts who are more engaged with new technologies and more mentally active. Such cohorts of older drivers may be experiencing less cognitive declines than the general older driver population. Therefore, the true age differences on attentional failures during driving in the general population may be larger than what was demonstrated in our results. Further data collection using more traditional methods such as phone calls and paper surveys from older drivers who dwell in local communities can address this issue.

We are continuing data collection on the survey study. With more data and further analyses, we expect to improve the construct of our questionnaire and look more into different categories of attention (e.g., age differences in each category). In addition, we plan to conduct laboratory studies to examine how self-report measures of attention are related to computerized attentional tasks and simulated driving. The laboratory study will provide additional examination of the validity of our questionnaire. Moreover, although AFDQ is primarily developed to measure attentional failures among older drivers, results from our study showed that the questionnaire may also be a useful measure for drivers in other age groups, particularly the younger drivers (age 18-25), as they reported high level of attentional failures and cognitive errors, and low confidence in driving.

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